

Use of Composite Products Is Growing

Composite products are an important and growing segment of the forest products industry. Over 70 percent of all wood materials in use today contain some type of adhesive, and that figure is expected to grow as new products and processes are developed. As supplies of virgin timber tighten, nonwood biomass fibers, such as straw, and recycled fiber products, such as paper and wood wastes, are being used as raw materials for composite products.

Composite products are an important and growing segment of the forest products industry. In the last 50 years, solid-sawn lumber and timber construction have given way to advances in composite technology. Within the industry, the term composite is usually used to describe any wood product that is glued together. Over 70 percent of all wood materials in use today contain some type of adhesive, and that figure is expected to grow as new products and processes are developed. Composites offer superior performance, reduced weight and volume, cost effectiveness, fatigue and chemical resistance, and controlled biodegradability. In addition to wood, materials such as plastics, glass, metal, synthetic fibers, and other biomass materials can be used to make composite products.

The timber products industry has evolved to utilize timber resources that are available. As the quality of timber resources has declined, new methods for processing and reconstituting forest products have been developed. This trend is expected to continue as future harvests from Federal lands will remain low due to environmental concerns. The forest products industry is conducting research in cooperation with USDA's Forest Products Laboratory and universities to develop new processes and materials to extend timber supplies and promote energy efficiency.

Composite Evolution Began in the 1950's

The original composite-panel product was plywood, which became popular in the 1950's with the development of phenolic adhesives. Plywood became a superior replacement for 1-inch-sheathing lumber used in housing frames. In the 1970's, the waferboard industry emerged, principally in Canada, using mainly aspen flakes glued together under pressure. In the 1980's, a refinement of this process was developed that cuts logs into long strands parallel to the grain, which are then oriented and blended with adhesives to produce a board with the outside layers oriented parallel to the grain and the center core with the short dimension. The panel is then pressed and cured. The resulting oriented-strand board (OSB) is similar to plywood in its applications. OSB generally costs slightly less than plywood, about 30 cents per square foot, and conserves wood use.

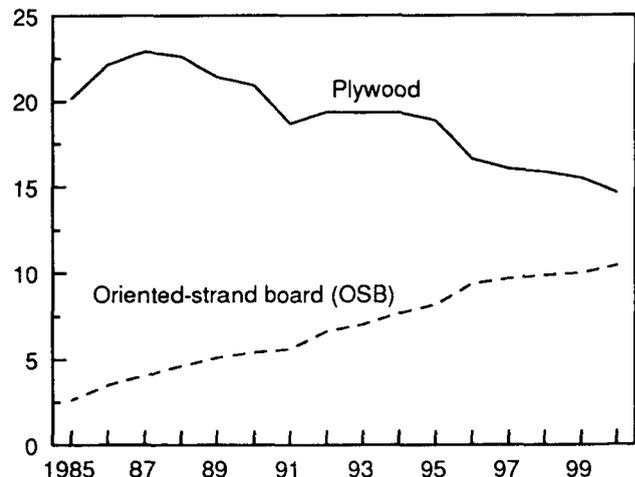
OSB production has been growing steadily in the United States since its inception. Production increased from 2.7 million square feet (3/8-inch basis) in 1985 to about 7.1 million in 1993. If present trends continue, OSB production in the United States will rise to 10.4 million square feet in 2000 (figure 4). Plywood production was about 20 million square feet (3/8-inch basis) in 1985 and then rose to about 22 million square feet in the late 1980's. In the 1990's, however, OSB displaced plywood in many uses, especially sheathing. Plywood production declined to 19.3 million square feet in 1993 and is projected to go down to about 14.7 million square feet by 2000.

Composite panel products can also be produced from nonwood biomass materials, waste wood, or wastepaper. Straw from wheat or barley has been proposed as a raw material for making particleboard that could be used as a building material. Agricultural fiberboards have been found to offer superior strength, heat and sound insulation, and resistance to fire due to their density compared to standard 2-by-4-inch lumber and sheetrock wall systems.

Figure 4

OSB and Plywood Use in the United States

Million square feet, 3/8-inch basis



1/ 1995-2000 projected.

Source: American Plywood Association.

A large-scale plant using up to 340,000 tons of straw annually has been proposed for North Dakota by Isobord Enterprises, Inc., of Toronto, Ontario, to produce a fiber-composite board. Another straw fiberboard plant is proposed for Montana using an established English system to compress straw into fiberboards. Other agricultural biomass projects are under consideration in Iowa, Kansas, Oregon, and other states.

Enviroboard is a product similar to OSB that uses 75- to 90-percent cereal straw combined with cement and adhesives. Made by Home Builders International, it is being used to build homes in South Dakota, Minnesota, and Wisconsin. Also, in Minnesota, Phenix Composite, Inc., is commercializing a new composite product called Environ, made of soybean monolithic resin and waste paper. According to the company, the material looks like granite but has the construction properties of wood. It can be manufactured into panels, blocks, or veneers and colored to simulate many granite hues.

New Technologies and Recycling Mean New Wood-Conserving Composites

Of the approximately 195 million tons of solid waste generated in the United States in 1990, about 40 percent was paper, 10 percent plastics, and 8 percent wood waste. While data are available for certain wood-based products in municipal solid waste, information is incomplete for timber thinnings, industrial production wastes, and sawdust. In 1992, 540 million pallets were produced. Many will be reused, but all will eventually require disposal.

Fiber-based waste products--such as paper, yard wastes, and solid-wood wastes--can be readily reduced to a particulate or fiber form suitable for composites. The potential exists for recycled wood fibers and plastics to produce a wide spectrum of products ranging from very inexpensive, low-performance composites to expensive, high-performance materials. New fiber technology, bonding performance, and fiber modification can be used to manufacture wood-plastic composites with uniform densities, durability, and high strength.

An existing, though not widely used, building product that can readily be adapted to use recycled wood material utilizes an inorganic binder, such as portland cement. Inorganic-bonded wood panels made with virgin untreated wood have very good strength properties, as well as excellent resistance to fire, fungi, and termites. This type of panel is being used in construction in Europe, Asia, and South America.

A cement-bonded product may be an efficient way to utilize preservative-treated recycled materials. Many end uses are predicated on good performance in harsh environments and because the product has a long-life

expectancy, it can tie up the preservatives for relatively long periods of time. Considering that over 60 percent of all the southern pine lumber cut today is treated with some sort of preservative, the presence of this material in the waste stream will likely increase.

Several specific technologies exist that have the potential for producing housing products from recycled wood waste. Technologies with the greatest potential for success include: Dry-formed reconstituted wood products from fibers, flakes, chips, or particles; wet-formed wood products from fibers; wood/plastic combinations; wood/cement combinations; reuse of old lumber from razed buildings; and remanufacture of lumber from short-piece wood wastes from construction sites. A significant advantage of utilizing recycled wood waste is the opportunity to depart from conventional framing and panel building systems.

"Reconstituted" describes a process where wood-waste materials are broken into small pieces and reassembled into new forms with the aid of an adhesive. Because the raw materials are from waste, recyclable wood comes in many different forms from many different sources. This poses special processing considerations. These include size reduction and necessary cleaning operations. Blending the wood pieces will reduce performance variations caused by species differences. Much of the technology currently used for manufacture of fiber- and particle-based wood products using virgin wood is transferable to recyclable wood. Commercially, wood fibers are used in all manner of fiberboard and can be molded into a variety of geometric shapes. One readily identifiable product made using this technology is interior door panels for automobiles.

Wood waste has the potential for use in wood-flake products as well. However, making wood flakes from recyclable wood may be the most difficult of all the technologies mentioned here. Therefore, flake technology will probably be most useful where the waste stream is very tightly controlled. The raw material should be softwood flakes with a high-moisture content and must be properly pre-sized to produce a consistent product. Flakes are commonly used to produce sheathing products, such as OSB. Flakeboards are also used as one or both skins in stressed-skin panels and for webs in wood I-beams.

Another process with potential for utilizing solid wood wastes, including lumber scraps and tree trimmings, involves crushing the wood into splinters. This process offers attractive advantages over other wood-reduction techniques since no cutting is required. Because they have high length-to-cross-section ratios, splinters are strong and can be highly oriented. Dry hardwoods splinter exceptionally well, so this technology seems like a natural outlet for used hardwood pallets. This splintering process

has shown potential in Australia, where a structural wood product called "scrimber" has been developed.

Research is currently underway at USDA's Forest Products Laboratory to produce both structural and nonstructural housing components from recycled wastepaper fiber. Using a three-dimensional pulp molding process, a structural housing component, spaceboard, is formed by draining a pulp slurry through a resilient mold. The mold is then hot-pressed to densify and dry the product. A preliminary study has demonstrated the potential of spaceboard as a floor panel product. This process can readily accept recycled wood fibers and has the potential for both curvilinear and three-dimensional solid formed products. This molding potential will greatly enhance the flexibility architects and engineers have in designing housing.

Another potential technology to use recycled wood fiber is a pulp extrusion process. A pulp slurry is dewatered, densified, and dried as it is forced through special dies. This process has the potential to produce products with various dimensions and cross sections, with essentially unlimited length. Potential products might include casing and trim products and lumber-type profiles.

A third type of wet-formed, fiber-based process involves shaping structural components through the winding of paper-sheet stock. This process incorporates existing sheet-forming technology, but has the potential to utilize recycled paper stock. A number of potential housing components can be produced this way, since many shapes can be formed.

All three of these technologies have potential to produce structural housing components, including studs and wall corner posts, interior and exterior sheathing, as well as beams and floor panels. Nonstructural (nonload bearing) elements are also possible. Gridcore Systems International of Carlsbad, CA, has licensed the spaceboard technology from USDA and is using it to manufacture Gridcore panels. The panels--which are made from recycled corrugated containers, newspapers, and wood waste--are used in furniture, movie sets, and stage displays. The company plans to expand portable applications and develop panels for use in the housing and construction industries.

What Are Future Needs?

A growing population will place greater demand on energy resources, increasing the demand for energy efficiency.

Greater demands on energy resources will require building designs that reduce heat loss in cold regions and minimize solar gain in hot regions. Population growth along coastal areas will increase chances of large population centers being hit by the heavy winds associated with these areas. The same is true for areas threatened by seismic activity.

Construction materials that contain recycled components that exhibit ductile/energy-dissipating characteristics would have special applications in seismic areas. Rigid materials and connections that resist high loads and then fail abruptly are more likely to result in extensive damage than those that exhibit plastic behavior and ductile failure. For example, cement-bonded-fiber composites exhibit a characteristic elasto-plastic load displacement. Research to improve their durability, connections, and panel configuration could result in a low-cost structural material that has good fire, insect, and decay resistance in addition to its seismic load advantage. Low-density, shear-resistant composites may have dual applications as shear walls and sound barriers for multi-family buildings.

Acceptance for any new product depends partly on its ability to show a definite economic advantage. Plywood, for example, was more than a one-to-one substitute for board sheathing: it offered reduced labor costs and application time, less waste on the job site, and improved lateral-load (earthquake, wind) performance. Once accepted, plywood completely replaced board sheathing. OSB, however, has offered no advantage other than price and there are still contractors who refuse to use it.

Molded products for housing construction open the market to innovative, energy-efficient, and wind-resistant structures. For example, moldable structural composites from recycled waste might be used to fabricate stress-skin-panel corners to replace the conventional three-stud corner. This would reduce heat loss, improve shear performance, and reduce wind pressures due to turbulence around building corners in heavy winds. These products also could provide more architectural possibilities than existing rectangular wood products. Shapes can be mass produced to form curved surfaces with little or no framing members, thus reducing labor and material costs.

High-density fiber composites from recycled waste could also be used as substitutes for wood flooring and could provide a good wear surface while being more dimensionally stable than solid hardwood flooring. Maintenance could be reduced compared to an open-celled wood such as oak. Possible applications could include bowling alleys, gym floors, and decorative office flooring. [Tom Marcin, (608) 231-9366]